about 40 feet above the floor of the roof platform on the top of the Weather Bureau building. Even under these conditions of exposure the results were entirely unsatisfactory from a meteorological point of view, as the record showed a decided upward movement of the air, especially when the horizontal movement was considerable and from the north and west. This result was due altogether to the upward flow of the wind in striking and passing *over* the Weather Bureau building.

It was not considered feasible to provide a better exposure on a more lofty support, and after several months the anemometer was removed.

It is highly gratifying to see that the question of exposure has been so carefully considered by Rev. Marc Dechevrens, and the only doubt in my mind is whether the anemometer on the tower is elevated sufficiently above the top platform of the tower to be entirely free of eddies and disturbances caused by its proximity. The meagre knowledge of these conditions afforded by an examination of the photographic illustrations of the tower does not enable us to form satisfactory conclusions. A proper exposure of the anemometer is, however, only one of the several serious difficulties connected with the problem of measuring the vertical motion of the air.

A similar difficulty is found in the installation of the anemometer, so that it shall be absolutely neutral in a strictly horizontal wind. It is obvious that if the axis of the anemometer is slightly inclined from the vertical, then a wind moving horizontally will have a small component of motion parallel to the axis of the mill, and will presumably cause it to rotate. We have, therefore, in this defect of installation, a source of error which it seems to the writer it is very difficult to avoid. To be properly exposed, the instrument must be on the summit of a relatively slender support. To make the axis strictly vertical under these conditions is by no means an easy matter. We apprehend that the flexure or yielding of the support under wind pressure, especially with great horizontal motion, may not be negligible.

In the case of the Dechevrens universal anemometer, it is not sufficient to secure perfect verticality for the axis of the vertical component mill only. The axis of the apparatus which orients both anemometers must also be made strictly vertical, and furthermore must possess such an adequate degree of rigidity that flexures and temporary displacements from the vertical are not possible.

Even supposing, however, that a sufficient approximation to verticality has been attained and maintained, there is still another source of instrumental error that must be corrected numerically or eliminated mechanically before a true interpretation of the records is possible. This has reference to the symmetry of the four vanes and arms constituting the vertical movement mill. It is easy to see that if the complex system of pressures acting on this mill when it is subjected to horizontal wind are not in perfect equilibrium, a continuous or at least partial rotation will be set up, and will be attributed to a vertical motion of the air; the mill will turn to a position where the wind will tend to hold it and prevent rotation, even should it be acted upon by a real vertical component of motion of feeble influence.

Finally, the vertical component of motion is at best very small, and any anemometer to measure it should be very sensitive. The instrument of the Dechevrens pattern furnished to the Weather Bureau by Richard is decidedly less sensitive than the anemometers commonly supplied to measure horizontal movement. The writer is of the opinion that a much more sensitive type of instrument is required.

It is hoped that the full report of the observations on the island of Jersey will show how and to what extent the several difficulties and sources of error discussed above have been overcome and eliminated.

So far as known to the writer the vertical movement anemometer has never been subjected to actual experimental calibration. The interpretations of its indications are based entirely upon a theoretical computation of the movement of wind per revolution of the mill depending upon the pitch of the blades. Until such an assumption is shown to be justified by experimental data the interpretation of the observations must be somewhat uncertain.—*C. F. Marvin.*

A STUDY OF SOME ERRORS OF KITE METEOROGRAPHS AND OBSERVATIONS ON MOUNTAINS.

By HENRY HELM CLAYTON, Meteorologist of the Blue Hill Meteorological Observatory, dated April 3, 1904.

In order to get the best results from the records obtained in the free air by means of kites at Blue Hill, the errors to which the records are subject have been carefully studied. Since the methods and conclusions derived from this study may be of service to others undertaking such investigations, it seems well to publish the results promptly.

It appears to be a common belief that errors may be eliminated from any set of measurements by taking hundreds of observations and averaging them. But this only eliminates the accidental plus and minus errors of equal frequency and value. Errors in one direction, or constant errors, are the rule and not the exception. Accordingly, in reducing the kite records obtained at Blue Hill great effort has been made to eliminate these constant errors. The reduction of the records has, therefore, been a much slower and more tedious undertaking than would otherwise have been the case.

Six possible sources of constant error have been recognized as influencing the records. These are (1) instrumental errors, (2) errors in exposure of instruments when comparing with standards, (3) errors in reading from meteorograms, (4) errors due to the local environment, (5) errors due to the observations being limited to certain weather conditions, (6) errors in determining vertical gradients, due to simultaneous changes in weather conditions at various heights while the instrument is moving vertically from point to point in the atmosphere.

(1)—INSTRUMENTAL ERRORS.

The meteorograph used at Blue Hill was made by Mr. S. P. Fergusson, and has been carefully calibrated, as described in the Annals of the Harvard College Astronomical Observatory, vol. 43, part 3. But in the rough usage attending kiteflying the instrument may be injured, and it is necessary to examine instrument and records after each flight for indications of such displacement of parts as would give rise to error. Changes in the positions of the recording pens in relation to the lines of reference on the charts are determined by comparing the meteorograph with standard instruments in a standard shelter before and after each flight. The differences are applied as corrections to reduce the readings of the meteorograph to those of the standard instruments. The errors of range are more difficult to detect than simple displacements of the zero of the scale, but are very important, because the instrument is likely to encounter much lower temperatures and humidities in the upper air than are encountered at the ground, and, if the corrections found at the ground do not remain the same aloft, where the readings are much lower, considerable error may result. The temperature and humidity usually change considerably between successive kite flights, so that this gives an opportunity for roughly testing the range each time. If any change is suspected, the instrument is recalibrated. Errors due to the flexure of parts of the instrument under various strains are also carefully sought for; such errors may be large unless the instrument is carefully built. In certain cases corrections are needed for the sluggishness of the instruments, but as there is risk of additional error in applying these corrections it has not been attempted at Blue Hill, except in the case of the humidity when the correction was apparent. On the other hand, an attempt has been made to avoid this error by ascertaining experimentally how long a time was needed for the instrument to acquire the observed conditions, and then reading the meteorograph curves at places where the instrument was stationary in height for the proper length of time.

(2)—ERRORS IN EXPOSURE OF INSTRUMENTS.

The best method of comparing the instrument with a standard is in a closed box with thick walls where the temperature is changing slowly and an active air circulation is kept up by means of a fan. This method was tried for a while at Blue Hill, but, owing to its inconvenience, the method most used is to compare the recording instrument with the observatory standards in the thermometer shelter in the open air. The free air near the earth's surface during the daytime is a confused mass of ascending and descending air currents of slightly different temperatures and humidities. These currents passing through a thermometer shelter cause rapid oscillations in temperature and humidity, and make it very difficult accurately to compare instruments in different positions and of different degrees of sensitiveness. The comparisons can be made much more accurately at night, and it is now customary at Blue Hill to compare the recording instrument with the standards during the evening or very early morning preceding the kite flight, and again during the evening following the kite flight. Another method of comparison which has been used elsewhere is to suspend the instrument in the kite before leaving the ground, and then with a psychrometer whirled in the open air near the kite determine the corrections necessary to apply to the recording instrument. This method is subject to considerable error, because the meteorograph in such a situation records a temperature two or three degrees higher than that shown by a thermometer in a shelter about a meter above the ground. This may be proved by exposing the meteorograph in the shelter and then in the kite while lying on the ground. The Fergusson, Richard, and Marvin meteorographs have all been tried in this way and give similar results. The thermograph tube in the Marvin meteorograph is perhaps better protected from terrestrial radiations than the others near the ground, but this instrument also shows the heating distinctly, even in midwinter when the insolation is weak, as

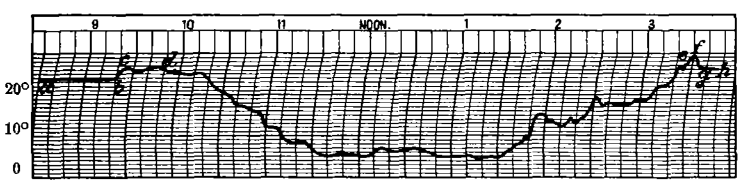

FIG. 1.—Influences of exposure of meteorograph.

can be seen from the accompanying chart, fig. 1, recorded on January 8, 1903. During the interval marked *a b* the thermograph was in the thermometer shelter; during the interval *c d* it was tied in the upper part of the kite which was lying on the ground; during the interval *d e* the kite and meteorograph were in the air at varying distances from the ground; during the interval *e f* the kite was again lying on the ground with the instrument suspended in it; and during the interval *g h* the instrument was again in the shelter. Now during the intervals *c d* and *e f* the temperature recorded by the kite meteorograph was evidently too high, and if, when the instrument is in such a position, a correction is found by means of a sling thermometer or a thermometer in a shelter, this correction will be too large to be applied to the records obtained when the kite is flying freely in the air and the corrected readings will all be two or three degrees too low. The result of applying a correction in this way would be to show an abnormal gradient in the temperature between the earth's surface and the place where the first value is derived from the kite record in the free air. In such a case the vertical gradient near midday might appear to exceed the adiabatic rate very greatly. The same result will follow if no correction is applied to the thermogram and the curves are read and used as they are recorded. It is found at Blue Hill that the greater the care taken to eliminate these errors the more nearly does the vertical gradient during the day approach the adiabatic rate.

(3)—ERRORS IN READING FROM METEOROGRAMS.

The greatest source of error in reading off the meteorogram is the time error. The different pens of a meteorograph rarely have the same time error, so that if on the same chart the heights are read from the barogram and the temperatures from the thermogram and the same correction for time error applied to each, the temperatures may be constantly too high or too low for the same altitudes above sea level. Furthermore, serious errors may be made in reducing the records of the meteorograph to the heights determined from theodolite measurements made at the ground, unless the time errors are accurately known. In order to keep a check on the time and allow for the sluggishness of the instruments, stops of five minutes or more are made from time to time when letting out the kites or reeling in. In addition, observations are made every minute during a large part of each kite flight at Blue Hill when the kites are visible, so that every rise and fall of the kites can be detected on the meteorogram. Another error in reading the charts arises from the thickening of the trace due to different degrees of vibration of the kites. In some cases error can be avoided by reading the middle of the trace, but in other cases the vibrations are not symmetrical on both sides of the mean, and experiments must be made to determine the proper portion of the trace to read, or the proper allowance for error. The stability of the kites and the rigidity of the instruments have recently been so much improved that this difficulty is not a serious one except in very high winds near the ground.

(4)—ERRORS DUE TO THE LOCAL ENVIRONMENT.

The place from which kites are flown may be subject to certain local conditions which would lead to error in interpreting the records. For example, the air immediately above a hill or mountain may be occasionally or permanently colder than the normal condition in the free air at the same height. Dr. Berson has shown that the temperature in the free air on the Brocken is lower than that found at the same height in the free air from balloon ascensions (Wissenschaftliche Luftfahrten, Band III, S. 89), and Mr. Dines has found that the temperature on Ben Nevis is lower than the temperature of the free air at the same height at a distance from the mountain.[1] At Blue Hill during the daytime, when ascending and descending currents are indicated by the kites, the temperature falls very uniformly with increase of height until a height of several hundred meters, usually the top of the ascending currents, is reached. When this uniform rate of fall is extended downward to the level of Blue Hill the temperature indicated for the free air agrees closely with the temperature observed on the hill. Moreover, when the vertical gradient of temperature is plotted by joining the temperatures recorded at the Blue Hill valley station with the temperatures recorded at the kites from 200 to 500 meters above sea level it is found that the interpolated temperature at the height of Blue Hill agrees closely with the observed temperature. The valley station is in a broad open valley and is about 15 meters above sea level. But probably the best test of this matter has been obtained during the past two years when temperature records simultaneous with those at the kite have been obtained at the top of a wooden tower built by Mr. Rotch near the base of Blue Hill. The top of the tower is about 30 meters above the general level of the surrounding land, and the exposure is as near

[1] Nature, vol. 68, p. 155.

a free air exposure as can be obtained. By plotting the temperatures observed simultaneously on this tower (78 meters above sea level) and at the kite, the temperature of the free air at 195 meters above sea level can be read from the plot and compared with the temperature observed at the same level on Blue Hill. The results are as follows, the minus sign meaning that the temperature on Blue Hill was lower, and the plus sign that it was higher than the interpolated temperature of the free air at that height:

	1902.				1903.			
Date	Aug. 7	Sept. 4	Nov. 6	Dec. 4	Jan. 8	Feb. 5	Mar. 6	Mar. 26
Difference in °F.	—0.2	+0.1	—1.0	0.0	—0.3	+0.2	+0.1	—0.5

	1903.						Mean.
Date	April 2	May 7	June 4	July 2	Dec. 3	Feb. 4	....
Difference in °F.	0.0	+0.1	0.0	+0.2	—0.1	0.0	—0.1±0.1

Most of these differences are the means of the results obtained during the ascent and the descent of the kite in each case. These figures indicate that during the day when the air currents are ascending and descending freely and the adiabatic rate of decrease prevails in the air the temperature on Blue Hill does not differ appreciably from the temperature of the free air at that height. In no case has the temperature on Blue Hill been found appreciably higher than that indicated for the free air.

At night, however, the temperature on the hill is lower than that of the free air at the same height. This can be ascertained by interpolating the temperature between the tower and kite, or more directly by comparing the temperature on Blue Hill with that recorded simultaneously by the kite meteorograph when it sank to the level of Blue Hill in the free air at a distance from the hill, as happened occasionally when the kites broke away and the flying line caught on some object in the lowlands. The following results were determined by the latter method. The minus sign indicates that the temperature on Blue Hill was lower than that in the free air:

Year.	1897.	1898.	1900.	1900.	1901.	Mean.
Date	Aug. 17.	Sept. 30	Sept. 21	Sept. 21	Nov. 8	....
Hour	10:50 p. m.	3:10 a. m.	9:17 p. m.	10:12 p. m.	9:17 p. m.	....
Temperature in °F	—2.3	—7.0	0.0	—4.7	0.0	—2.8

This cool stratum is usually not more than 50 to 100 meters thick. When the kites are being reeled in at night the kite meteorograph generally shows a uniform rise of temperature with descent until it is within less than 100 meters of the top of the hill, where a sudden fall of temperature occurs.

The fact that the air immediately above the hill is not appreciably heated during the day appears to prove that there is no heating of the air by radiation from the hill itself in addition to the heating by radiation from the ground in general. Conversely, since poor absorbers are poor radiators it may be inferred that radiation from the air to the hill does not cause a cooling in excess of cooling of air in general at the same height. The air passes too rapidly over the hill for radiation to act to any appreciable extent.

The observed cooling might result from either one of two distinct causes or from both combined. (1) The air blowing across the hill may be cooled by contact with the surface of the hill which is chilled by radiation. (2) The air striking the sides of the hill may be driven upward and cooled adiabatically when the decrease of temperature in the free air with increase of height is less than the adiabatic rate. This latter cause of cooling seems to be the chief one, because when the adiabatic rate does not prevail in the free air, the cooling above the top of the hill appears in the daytime. On December 8, 1900, when the sky was covered with dense nimbus clouds and a strong southerly gale prevailed, observations between 11 a. m. and 1 p. m. showed that the air was cooler on the hill than at the kite between 100 and 200 meters above the hill, or at the valley station 180 meters below the hill. The tower station was not in operation at that time. At 11:46 a. m. the temperature on the hill was 1.7 °F. lower than at the kite 127 meters above the hill. Again on November 6, 1902, under similar weather conditions at 4:40 p. m. the temperature was 0.8° F. lower on top of Blue Hill than at the kite 205 meters above the top of the hill, and was 3.0° lower than at the tower station, 117 meters nearer sea level than the top of the hill. The temperature on the hill was also 3.1° F. lower than that at the valley station, and 2.0 °F. lower than that of the free air at the height of the hill as determined by interpolation between the kite and tower. If cooling by contact with the soil were the cause of these differences the cooling ought to have been greatest at the valley station. It is interesting to note in this connection that the adiabatic rate prevailed between the valley and the hill, notwithstanding the fact that the time was within eight minutes of sunset, and the rate of decrease was much less than the adiabatic rate in the free air up to the height of 1500 meters. The same cooling at the top of the hill showed during a snowstorm with easterly winds on January 8, 1904, at 4:28 p. m., when Blue Hill was 2.8° F. colder than the free air as determined by interpolating the temperature between the tower and kite, which at that time was only 66 meters above the top of the hill. The adiabatic rate prevailed between the tower and the hill, but at no other point in the air.

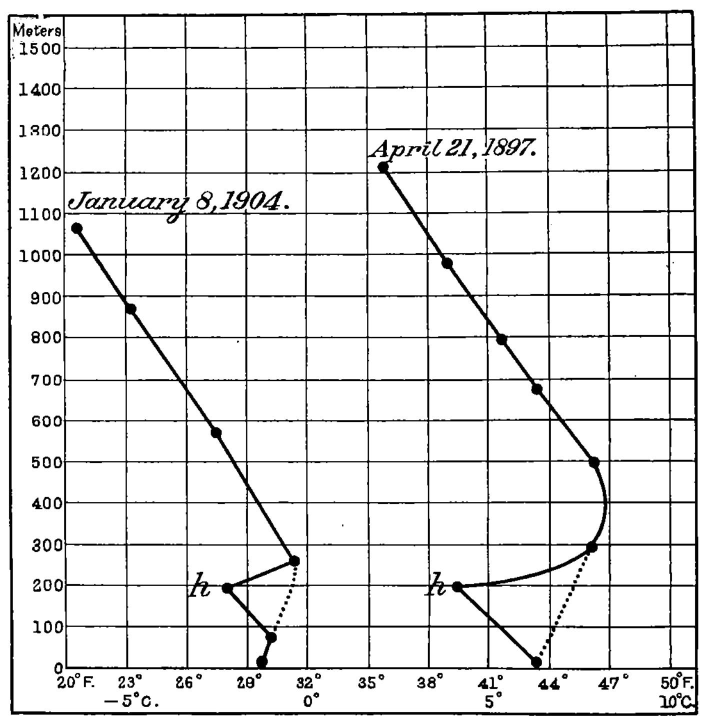

FIG. 2.—Distribution of temperature with altitude.

The vertical distribution of temperature as observed on the afternoon of January 8, 1904, is plotted in fig. 2, as is also the vertical distribution observed on the evening of April 21, 1897. The first is a good example of the cooling of the air above the hilltop during the day in cyclonic conditions, and the second a good example of the cooling of the air above the hilltop during the night. The continuous line connects the observed values while the dotted line indicates the probable temperature of the free air, which was evidently several degrees higher than that recorded at the top of the hill h h, 195 meters above sea level.

These results show that the mean temperature of the air on the hill must be lower than the temperature of the free air at the same height because the temperature on the hill never rises appreciably above the temperature of the free air but frequently falls considerably below it.

Since the mean temperature above every peak that has been compared with the temperature of the free air at the same height has been found cooler than the free air, it follows with a high degree of probability that the air above all mountain peaks averages colder than the free air, and as the chief cause is evidently the adiabatic expansion of air driven up the sides of the peak, the difference between the temperature of the peak and the free air probably increases with the height of the peak. From the conditions observed at Blue Hill it is easy to compute that the temperature above the tops of such peaks as Mount Washington, Pikes Peak, the Säntis, and the Sonnblick might be 15° to 20° F. colder than the temperature of the free air at the same height. At Blue Hill, and probably elsewhere, this cooling is greatest in cyclonic conditions when the wind is driven up the sides of the peak with greatest force.

If the air passing over a peak is cooled more than the surrounding air it will sink to a lower level than the top of the peak on the leeward side on account of the greater specific gravity of the cooler air. That this condition exists at Blue Hill is evident on days when clouds are passing somewhat above the summit of the hill. These clouds are seen to sink below the level of the top of the hill on the leeward side and do so for hours in succession.

(5)—ERRORS DUE TO THE OBSERVATIONS BEING LIMITED TO CERTAIN WEATHER CONDITIONS.

It is sometimes supposed that records obtained by means of kites are confined to certain weather conditions. For example, it is supposed that the records are obtained chiefly when the wind is above normal and not at all when the wind is very light. The kite, however, is not necessarily thus limited. The pressure, temperature, and wind velocity on the days of kite flights at Blue Hill do not differ in the average from the mean obtained from all the observations at the observatory taken in all conditions of weather; records have been obtained with the kites in all kinds of winds at the earth's surface, varying from a calm to a gale.

(6)—ERRORS IN DETERMINING THE VERTICAL GRADIENTS DUE TO SIMULTANEOUS CHANGES IN THE WEATHER CONDITIONS AT VARIOUS HEIGHTS WHILE THE INSTRUMENT IS MOVING VERTICALLY FROM POINT TO POINT IN THE ATMOSPHERE.

Since the weather conditions sometimes change rapidly while a kite is moving from point to point in the air, great care is needed in comparing records obtained at different levels; different conditions assumed to be due to differences of level may in reality be due to changes taking place simultaneously at both levels. A temperature gradient derived from the record of a kite meteorograph during the day may sometimes seem to exceed the adiabatic rate when the temperature of a large mass of the atmosphere is falling. For while a kite is rising from one point to another the temperature decrease shown by the meteorograph is the normal decrease with increase of height plus the decrease taking place in the body of the air.

The errors included under (5) and (6) will be considered in greater detail in the discussion of the observations in the Annals of the Astronomical Observatory of Harvard College, for which the above is a preliminary study.

MR. GIDEON S. JONES.

Mr. Gideon S. Jones, Assistant Observer, Weather Bureau, died at Columbus, Ohio, March 9, 1904, after an illness of three weeks, due to typhoid-pneumonia. Mr. Jones was born in Oxford, N. C., January 10, 1868. Most of his boyhood was spent at Madison, Wis. He entered the Weather Bureau in 1892 as an assistant observer. His duties were performed at the following-named points: Norfolk, Galveston, Charleston, Cincinnati, Yankton, Des Moines, and Columbus. He was a kind hearted and genial companion and popular with his associates.

THE TRANSVAAL OBSERVATORY.

By R. T. A. Innes.

This new meteorological institution is built on a range of hills 3 miles northeast of the city of Johannesburg. Its altitude is 5900 feet above sea level. Its latitude is 26° 6′ south. The instruments now being fixed there included a Sprung-Fuess barograph, a Dines-Baxendell anemometer and pressure plate, Callendar platinum resistance thermographs, Callendar sunshine recorder, Hoser lightning recorder of the type sent to the St. Louis Exhibition, Zeiss distance finder for work on clouds, Halliwell rainfall recorder, as well as complete sets of the more usual meteorological instruments. There are 24 outside barometer stations mostly at altitude of 4000 feet or more, and 198 rainfall stations, but the authorities are endeavoring to double this latter number in the coming season.

CLIMATE OF SIBERIA, KOREA, AND MANCHURIA.

By Prof. E. B. GARRIOTT, in charge of Forecast Division.

Korea and Manchuria may be compared in area and latitude with the group of Atlantic States of the United States that extends from North Carolina to Massachusetts. The climate of this region differs materially, however, from that of the eastern part of the United States. In eastern Asia the summers are short, with warm days and cool nights, the spring and autumn seasons are transitory, and the winters are long and cold.

Meteorological records at Vladivostok, which has about the same latitude as Boston, fairly represent the climate of northern Korea and adjacent parts of Manchuria. In those regions the monthly mean temperature remains below freezing from October to April, and the surfaces of the rivers serve as highways of travel five and six months in the year. At Vladivostok the annual mean temperature is 40.2°, as compared with 48.6° at Boston. At Boston, however, the monthly mean temperature is below freezing only during December, January, and February, with the lowest mean, 27°, in January, as compared with 7.4° at Vladivostok for the same month.

THE COLD OF SIBERIA.

In Siberia, along the line of the Transsiberian Railway, the climate is very severe. Great mountains shut off this region from the moderating influences of the oceans to the east and south, and from October until late in the spring it is exposed to the sweep of cold winds from the Arctic Ocean.

Lake Baikal, which cuts the line of the railway, and the region thereabouts is subject to heavy falls of snow, and the monthly mean temperature is above freezing only during July, August, and September. During the three winter months the monthly mean temperature at Lake Baikal is below zero, with the lowest mean, 6.8° below zero, in January. As a result of the low temperatures Lake Baikal is usually frozen to a great depth by January and remains in that condition three or four months.

The maximum temperatures of the short summer seasons in Siberia, northern Manchuria, and northern Korea are quite high and frequently range above 90°, even as far north as Verkhoyansk, where the January mean temperature is 56.2° below zero and the lowest absolute minimum temperature noted on the earth's surface, 90.4° below zero, has been recorded. Over a great part of Siberia, in fact, mercury often freezes in November, while in December, January, and February mercury remains frozen for weeks together in southern Siberia.

MANCHURIA AND COREA.

Manchuria, as a whole, possesses many fertile valleys that